A Historic Appraisal of Deccani Karez – Challenges and Prospects

V. Govindankutty[1]

[1]. Department of Geography, Government College Chittur, Palakkad, Kerala – 678 104, India *(Email: vgovin@gmail.com)*

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Abstract: *Karez /Qanat (underground aqueducts) in India have long been an enigma. Researchers are now rediscovering the unique characteristic and significance of these historic water systems. They have shown that the topography and geology on peninsular India contribute to unique morphology of Indian Qanats and explain how they diverge from Persian Qanat technology from which they were adapted. First developed in the medieval period, their spatial distribution is restricted to the semi-arid Deccan region of peninsular India. The Deccani Qanats thus, made it possible for deviation from traditional practice of establishing cities along major natural water bodies. Bidar, Burhanpur, Bijapur, Aurangabad, Ahmednagar and Hukeri are historic Decani urban centres that were Karez systems were constructed, and some of which survive to this day providing potable water to urban communities. These urban centres are in water stress due to geographical and anthropogenic reasons, the centralized piped water supply isn't accessible to all and come under severe stress especially during summer droughts. While the historic water systems in some of these urban centre's function through the drought and thus increasing their significance for conservation and development as decentralized urban water supply systems. Off late the unplanned organic growth of these historic medieval cities, coupled with lack of awareness, understanding of conservation practices and policies have resulted in an unsustainable geophysical alteration of the fragile hydraulic landscape leading to destruction of many Karez Systems.*

Keywords: Karez, Qanat, Kharejari, Surang-Bhawi, Deccan, Conservation, Urbanization

Introduction

'Karez', 'Qanat', or 'Kariz" literally means subterranean channel in Persian (Houtsma, 1913). It is a system that collects and conveys groundwater for anthropogenic needs. Karez are gently sloping gravity tunnel constructed mostly below water table in variety of geology and biogeographical zones to harvest transport and distribute water from source to point of use and connected to the surface by a series of shafts or vents nearly at equal interval (Govindankutty, 2013; Beaumount, 1971; English, 1968) (Figure 1). The Karez is known in a variety of names in different parts of the world (Table 1). Persian region is known for high density of functional qanat systems in world, Iran has about 38000 functional Qanat systems (ICQHS).

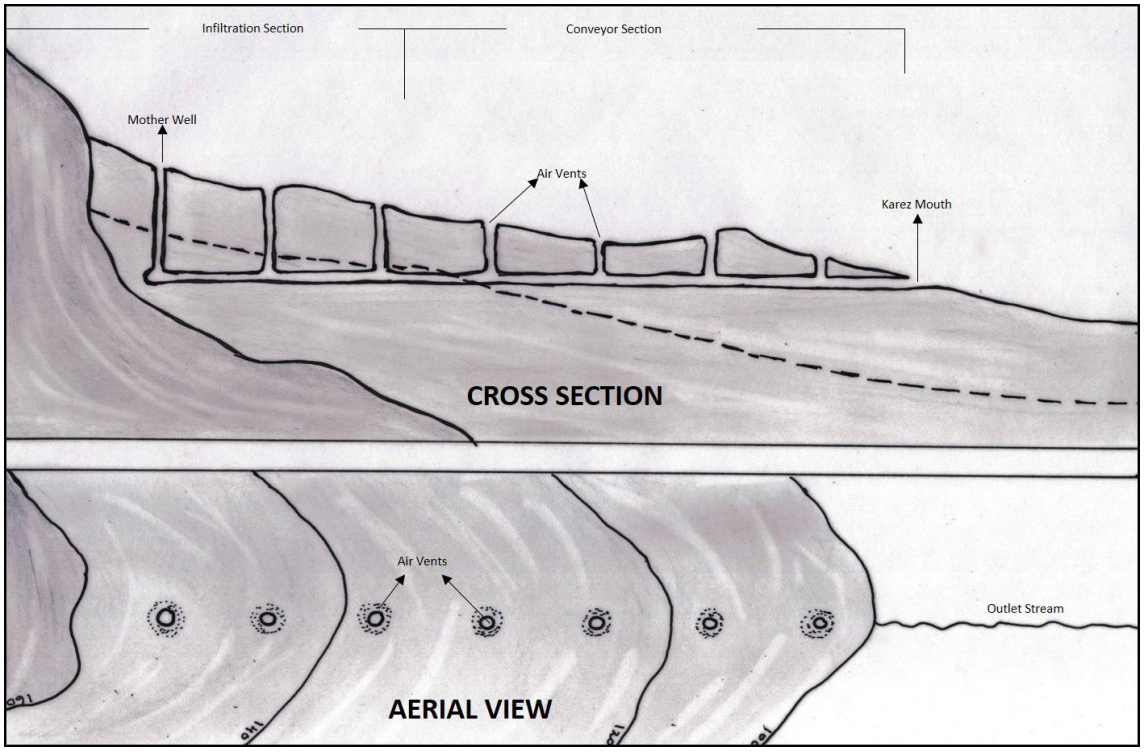

Figure 1: A cross-section view of Karez

Table 1: Local Names of Karez

Countries	**Local Names**
Iran	Qanat
Iraq	Qanat, Karez
Saudi Arabia, Oman	Aflaj, Falaj
India	Karez / Kariz / Kharejari / Surang-Bawdi / Nahar / Kundi Bhandara
Afghanistan, Pakistan	Karez / Kariz
Spain	Gallerias, Mayrit
Morocco	Khattara, Rhettara
Algeria	Foggara
Italy	Ingruttato /Ingruttati
China	Kanjing, Kanerjing, Karez
Korea	Man-nan-po
Japan	Mambo, Mappo
Latin America	Galleria, Puquio
Syria	Qanat Rmani
Yemen	Felledj, Ghail, Miyan, Sahzidj

**Compiled by author*

The initial documentations on Karez could be found in the form of historical memoirs or writings by travellers. Polybius (c. 200 – c. 118 BC) while describing the eastern

campaign of Antiochus the great in 206 B.C mentions existence of Karez in northern edge of the desert under the Alburz (Taurus). In the description he uses the term '*hyponomoi*' to denote qanat. This description does indicate existence of qanats during Achaemenid times in Persian region.

Conventional thinking is that the Karez technology originated from Persian region and spread through the trade routes to Asia, Africa and the West (Abbie Bowman, 2016). Beaumount (1971) mentions that the Karez are one the most impressive technological advances in extraction of groundwater that took place in Iran about 3000 years ago. Countering this Magee (2005) identifies oldest Karez to Oman and with development of concept it spread to other arid countries. Perhaps this is one traditional technology which has survived the times even with advancement in well drilling technologies. The number of active Karez stands testimony to this. One of the most acceptable viewpoints is that Karez originated in pre-Achaemenid Persia and further spread to Egypt, Levant and Arabia (Asghar, Yazdi, & Khaneki, 2013; English, 2010; Gobolt, 1979). It was the Arabs who carried it to rest of north Africa, Spain and cypress which further spread to western nations as well (English, 1968). There is more of a consensus with regard to western Iran and eastern Turkey as location of origin of qanats some 2500 to 3000 years ago (Asghar, Yazdi, & Khaneiki, 2012). The innovation is associated with mining ventures in the region is considered as initiation period of Karez technology (Gobolt, 1979). An argument presented on Karez origin to Kasaragod district in Kerala (Nair, 2016), is not corroborated with appropriate evidence, hence could be out rightly rejected (Crook , Tripathi , & Jones, 2015).

Since Achaemenid era Karez technology has been watering the villages in Persian region. Karez system represents a traditional response to the problem of water supply and is particularly characteristic feature of the landscape of Iran (Beaumount, 1971). Underground channels are characteristic signature of Persian villages (Fisher, 1928). Several qanats rise from mountains and lead to villages in lower basins, with wells about twenty yards apart is typical Iranian landscape (Fisher, 1928). Diffusion of Karez systems (Figure 2) to other parts of the world happened through trade relations, knowledge transfers through migration of influential and skilled class of people to other parts of the world like India. The Persian influence towards south and west lead to Karez technologies taking shape in Africa and Europe (prominently in Greece, Italy and Spain). The Silk route connecting Persian with China was not just a trade route but network that connected several communities together resulting in knowledge transfer. Some of the Kings and Sultans in Deccan region are of Persian lineage as well, who patronised the skilled engineers and artisans from their home land (Sherwani, 1985), resulting in arrival of Karez technology in India (Yazdani, 1944).

All the Karez systems in India were constructed between 15th and 18th Century ACE and is spatially distributed in Deccan region of India. This was very active period of urbanization in Deccan with establishment of urban centres like Bidar, Bijapur, Aurangabad, Ahmednagar etc. Karez became the primary water supply for all these

urban centres catering potable water to citizenry, watering gardens and agricultural farmlands.

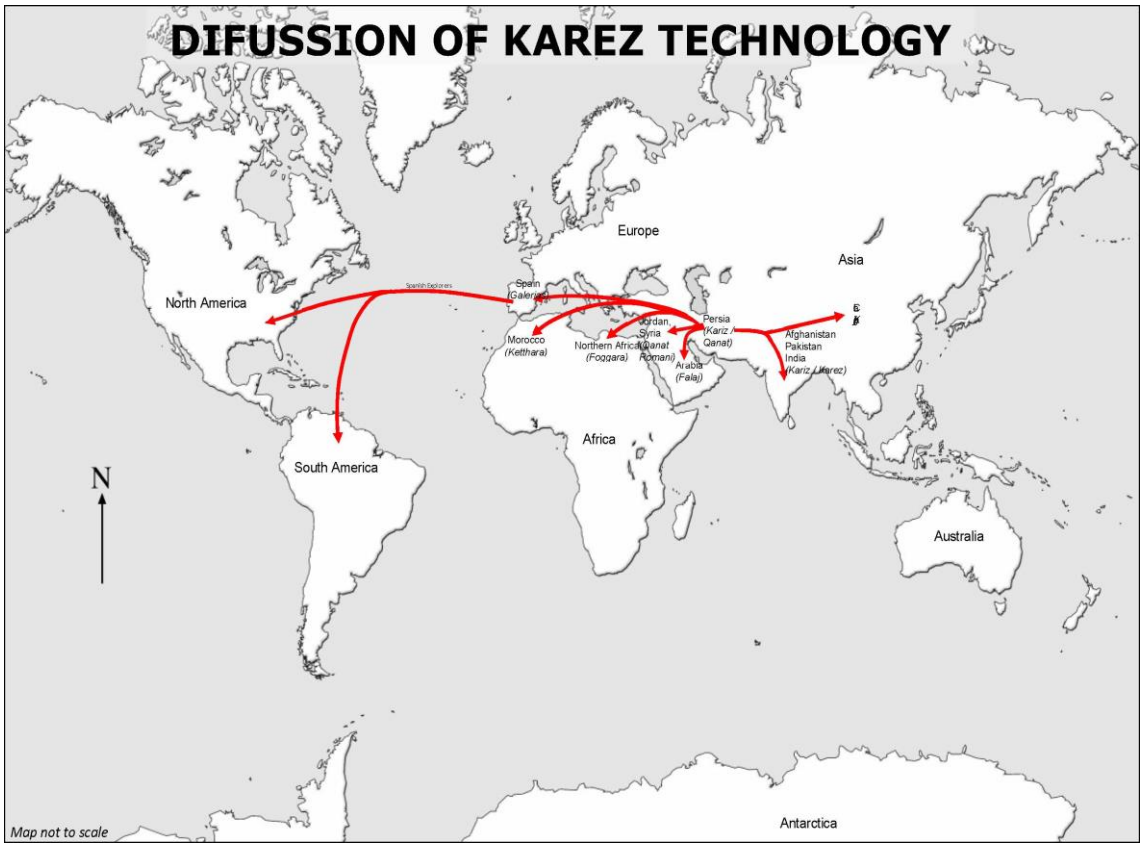

Figure 2: Diffusion of Karez Technology

Spatial Distribution

The Spatial distribution of Karez is limited to Deccan region of India. The Spatial distribution near about coincides with the Deccan Sultanate extends (Figure 3). Off the existing Karez, Bidar, Bijapur and Hukeri are in the state of Karnataka, Ahmednagar and Aurangabad in Maharashtra and Burhanpur in Madhya Pradesh are the known locations of Karez systems in India.

All the Karez systems were constructed in different time periods and by different Deccan dynasties, with varying spread and extend of their territories. As one dynasty fades away into the history and new ones occupy these territories. The understanding of the Deccan landscape's geographical setting and resourcefulness of the rulers is reflected in the way they have constructed and managed the Karez systems.

Geographical Setting

Interestingly all the Karez systems are in Deccan region of India (Figure 3). The Deccan region is undulating plateau, with an average elevation of 600m above sea level (Vaidyanadhan & Ramakrishnan, 2010). The region is known for sequence of volcanic deposition called Deccan traps (Radhakrishnan & Vaidyanadhan, 2011).

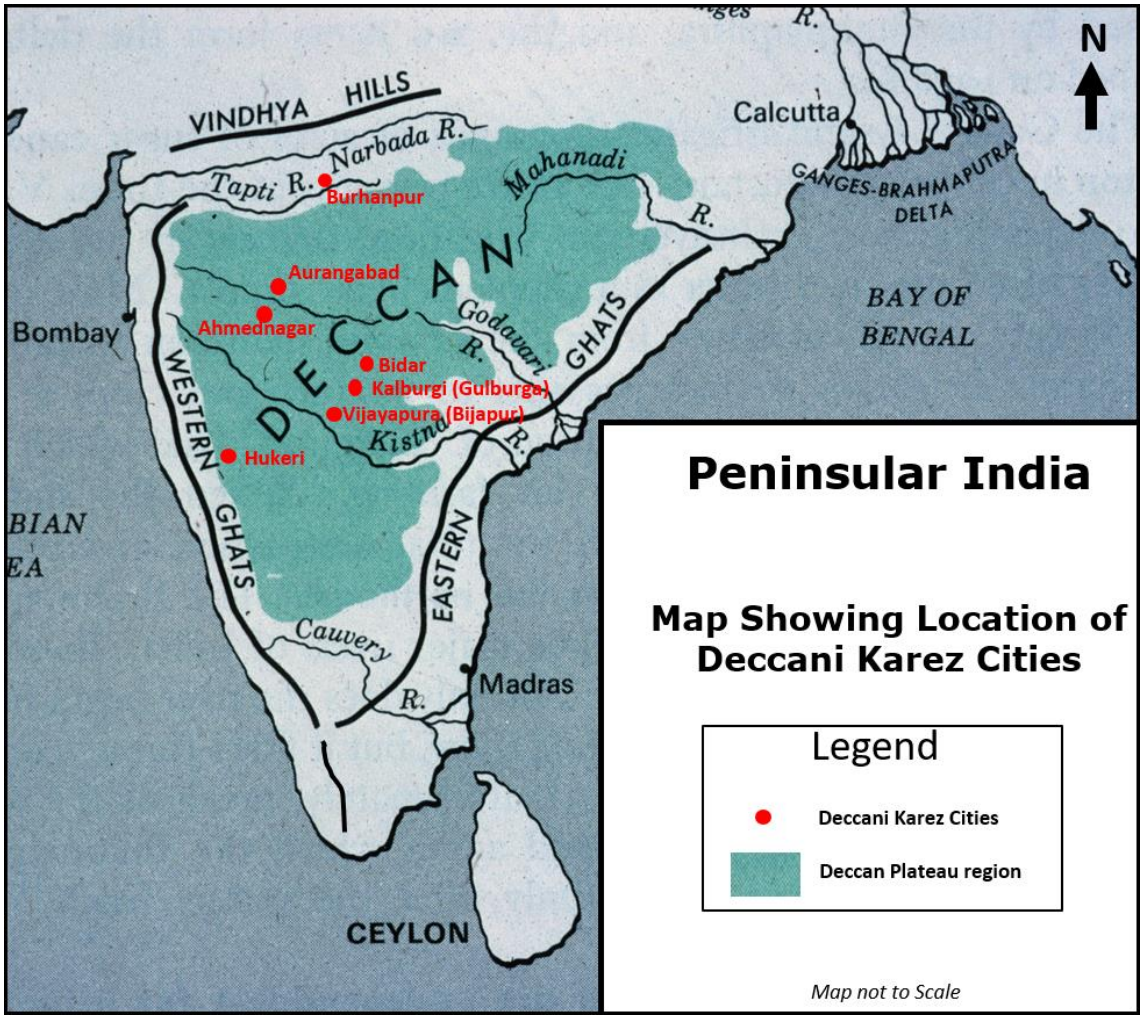

Figure 3: Location of Deccani Karez Cities

Deccan traps is the second most dominant unit next to the basement complex in Peninsular India but far more enigmatic in hydrogeological characteristics (Pawar, Das, & Duraiswami, 2012). The Deccan traps cover 5,10,000 square kilometres of area covering Maharashtra, and Parts of Madhya Pradesh, Telangana and Karnataka. The Deccan traps were result of effusive outpouring of volcanic lava through fissure eruptions. The lava outpourings during Cretaceous and Eocene were flood basalt that piled up almost in horizontal sheets characteristically uniform in composition. These horizontal layers have a thickness of 6 to 61 meters with weathered and vesicular layer on top followed by fractured massive units forming fairly good aquifer (Radhakrishna, 2007). Presently black soil, the resultant of weathering and erosion occupies the top layer. With high water retentive qualities, the soil promotes agriculture in this region, but severely impeded by low rainfall being on leeward side of Western Ghats. The Deccan regions with exception peripheral areas receive less than 100cms of rainfall annually. Thus, groundwater is one of the main sources of water for household, irrigation and industrial use. Several rivers and its tributaries have carved out valley's flowing south easterly into Bay of Bengal. Godavari and Krishna being the mighty

one's, yet all are non-perennial in nature. The Karez systems were developed in response to the physical conditions offered by Deccan landscape for abstraction of groundwater in a sustainable way.

The plateau is undulating in nature after having undergone millions of years of differential erosion. Weathering and chemical transformation has also resulted in formation of laterites which can be extensively seen in Bidar Plateau (Radhakrishna, 2007; Radhakrishnan & Vaidyanadhan, 2011). The Karez Systems of Bidar have been dug into the lateritic terrain, which overlies the Deccan trap in these parts. While at Bajpur, the shallow tunnels of Kharejari cuts through alluvial soil and vesicular Basalt layers and the deeper section pass through hard basaltic rocks.

At Aurangabad and Ahmednagar, the Nahar systems are shallow, mostly constructed by open trenching method in alluvial soil and vesicular basalt. The sides of the trench are lined with brick and lime mortar. The roof is either made of bricks or basalt stone slabs.

At Burhanpur the system originates from alluvial fans emerging along southern side of Satpura ranges sloping towards Tapi river. These alluvial depositions are criss-crossed by several run-off channels running south. The Mother well is constructed along such channels which ensures higher infiltration. The soil is loose hence tunnelling is difficult, thus the engineers have used brick and lime mortar lining inside, protecting it from collapsing.

The survival of karez systems even to this day without any maintenance is a reflection of how then engineers did overcome the challenges posed by geographical setting in construction of (Crook , Tripathi , & Jones, 2015)Karez systems in Deccan region and made it sustainable in long run.

Historical Review of Karez Systems in India

Very little was known about existence of Karez in India, except to that of Burhanpur and Aurangabad. But the research work by author has led to rediscovery of many more. These rediscoveries have led to identifying critical difference in morphology, region and character defining elements of Indian Qanat/Karez.

It's unknown when the Qanat/Karez technology arrived in India. The spatial distribution is limited to Deccan region with semi-arid conditions, coinciding with Deccan sultanate territories. These were constructed during medieval times, possibly in the chronological sequence kingdoms established in the region (Table 2). Though Daulatabad was prominent during medieval period the urban water supply system is different being located on top of a 300m high hill. The city of Burhanpur and Aurangabad came into prominence much later in the medieval times. Bijapur, Ahmednagar and Hukeri developed into prominent centres during Bahmani period and continued to prosper under subsequent rulers. Thus, the highest possibility lies

with Bidar, the Capital of Bahamani kingdom for having constructed the first ever Karez system in the Country.

Table 2: Chronological order of Karez Systems in India

Sl. No.	Location	Number of Karez Systems	Construction Time	Kingdom
1	Bidar	3	15th Century ACE	Bahmani
2	Ahmednagar	15	15th - 17th Century ACE	Nizam Shahi
3	Bijapur	1	16th Century ACE	Adil Shahi
4	Hukeri	1	16th Century ACE	Adil Shahi
5	Aurangabad	14	16th Century ACE	Nizam Shahi
6	Burhanpur	1	17th Century ACE	Mughal

** Compiled by author*

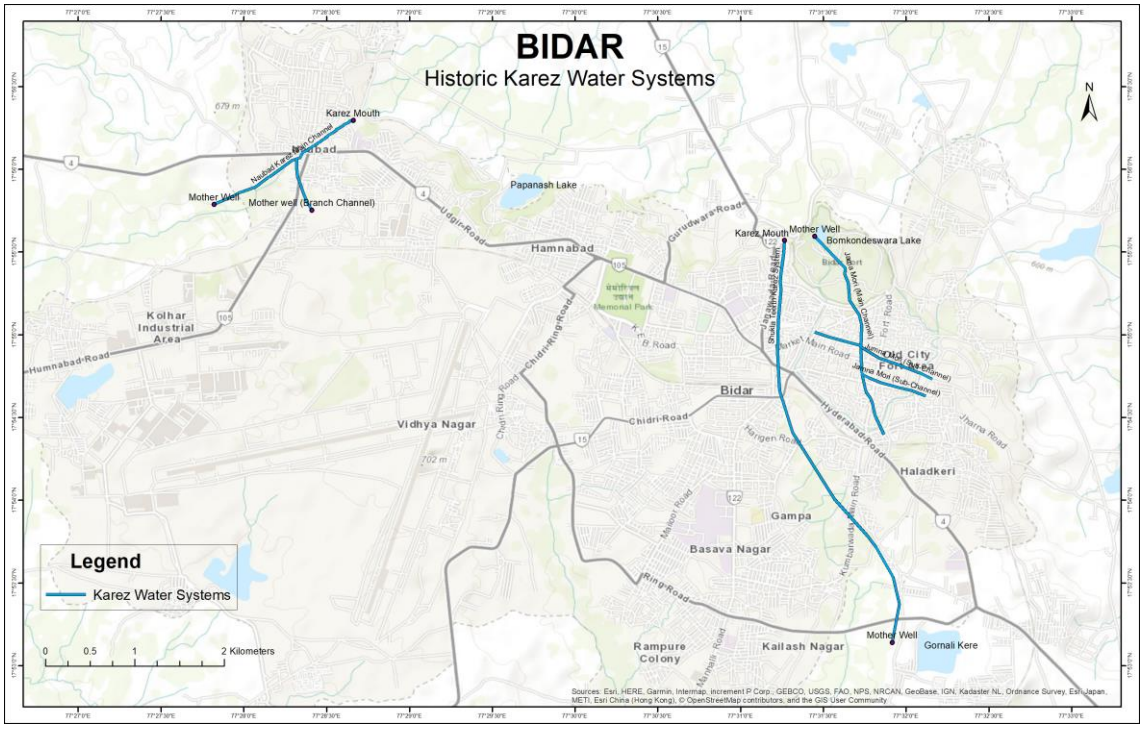

Figure 4: Historic Karez Water Systems of Bidar

There is very little evidence in terms of historical documentation on Karez systems in India. The best of these evidence is available on three Karez cities Aurangabad, Ahmednagar and Burhanpur. Which have extensively been documented and used as city water supply system during the British Period in India (Gazeteer of Aurangabad, 1884). The earliest mention of Karez could be found with respect systems in Bidar in Marathi Bakhar literature written in praise of Bahmani rulers, which describes their agility in developing water infrastructures for irrigation and domestic purposes (Kulkarni R, 1972). Most translations of historic documents of this period and inscriptions written in Persian reveal such massive projects were given priority. Water

supply was most important state provided service to the citizens. Patronage was provided for skilled engineers from Persian region by Deccan dynasties which ensured innovation in water supply technologies. A vivid city wise description of the Deccani Karez systems is provided below with maps.

Karez Systems of Bidar

Bidar Karez systems are the first ever, constructed in India. The chronological emergence and establishment of Deccani cities indicates to this probability. The Bahmani dynasty initially established at Gulburga, shifted its capital to Bidar during 1427 and was responsible for its growth and prosperity (Yazdani, 1944; Sherwani, 1985; Bahadur, 1894). Bidar has three Karez systems. Two systems exclusively serve the Royal and public fort enclosures (old city) of Bidar (Figure 4). First of these systems was constructed during the period the period of Ahmed Sha Wali (Kulkarni R, 1972), The System that serves the old city and passes right under it between triple moat and *Fateh Darwaja*, is called the *Jamna Mori* (Yazdani, 1944) . The Second system runs along the northern side outside the fort walls called the *Shukla Theerth* (Yazdani, 1944) and is the longest Karez in Bidar. The third system called the Naubad Karez System (Govindankutty, 2013; 2016; 2018) is fairly in better state with initiation of conservation process during 2015. The Karez are better known as '*Surang-Bawi*' to the local community. *Surang-Bawi* literally means a tunnel connecting many open wells.

The *Jamna Mori* systems is the most secure water system of Bidar, as the entire system is within the two fort complexes (Yazdani, 1944). The system starts from *Bomakondeswara* lake inside royal enclosure and flows through the old city and empties into moat near *Fateh Darwaja* (one of the city gates), a channel further carries water for irrigation. This system has a network of branches from the main line serving all corners of the city area. The access to this system is near about closed, one such access could still be seen within residential area near *Fateh Darwaja*. It's a narrow, steep and small stairs leading into the Karez gallery. The stairs have been cut into the laterite bed. The system is still functional, one could locate water in most of the identified vents, but it seems to have been polluted due to lack of awareness, both to general public and civic authorities about these water systems, hence many locations sewerage lines have been connected to the system. The waste water getting accumulated in the moat, where all sewer lines end from old city, accentuates the pollution. The *Jamna Mori* once the life line of Bidar city and is likely to become the cause for out-break of diseases.

The *Bomakondeswara* lake waters recedes during dry season, hence to enhance the water levels of a second Karez systems was developed presently called the *Shukla Theerth,* is also the longest of Karez systems at Bidar (Govindankutty, 2018). It starts six kilometres to the south west of city near a Gornalli embankment. The main line of the system passes north of both the fort wall and culminates at the plateau cliff. The system has several distribution channels serving the outer part of the city, one of the channels probably connects with *Jamna Mori* to increase the supply to the city during summer season. During survey two vents were discovered indicating a channel in this

direction. This Karez line also served the royal enclosure moat, a surface channel from this moat further leads the water to *Bomakondesware* lake. Just below the plateau cliff where the system culminates basalt stone (destroyed during development process in 2015) lined channels take the water to a tank of 25sq m in size, from where terracotta pipeline covered in thick lime concrete carried water to Agrahara village (Yazdani, 1944)

The third Karez system was developed 4km North west of Bidar fort to develop a new settlement (Yazdani, 1944), which was later abandoned. This system called Naubad Karez is still functional though the debris deposited blocks the channel (Govindankutty, 2013). The system is 3.28km long (inclusive of branch gallery, bypass channels and distribution channel) and has two mother wells. The Naubad Karez landscape stands out as example for good watershed management practice similar to other Karez systems in India. An attempt to rejuvenate the system was initiated during 2015 by the government of Karnataka but was abandoned midway. The debris removal showed the prospects of the one and only Karez system that can be completely revived in India. It also has a potential to serve as a decentralized water supply source for domestic and agricultural use.

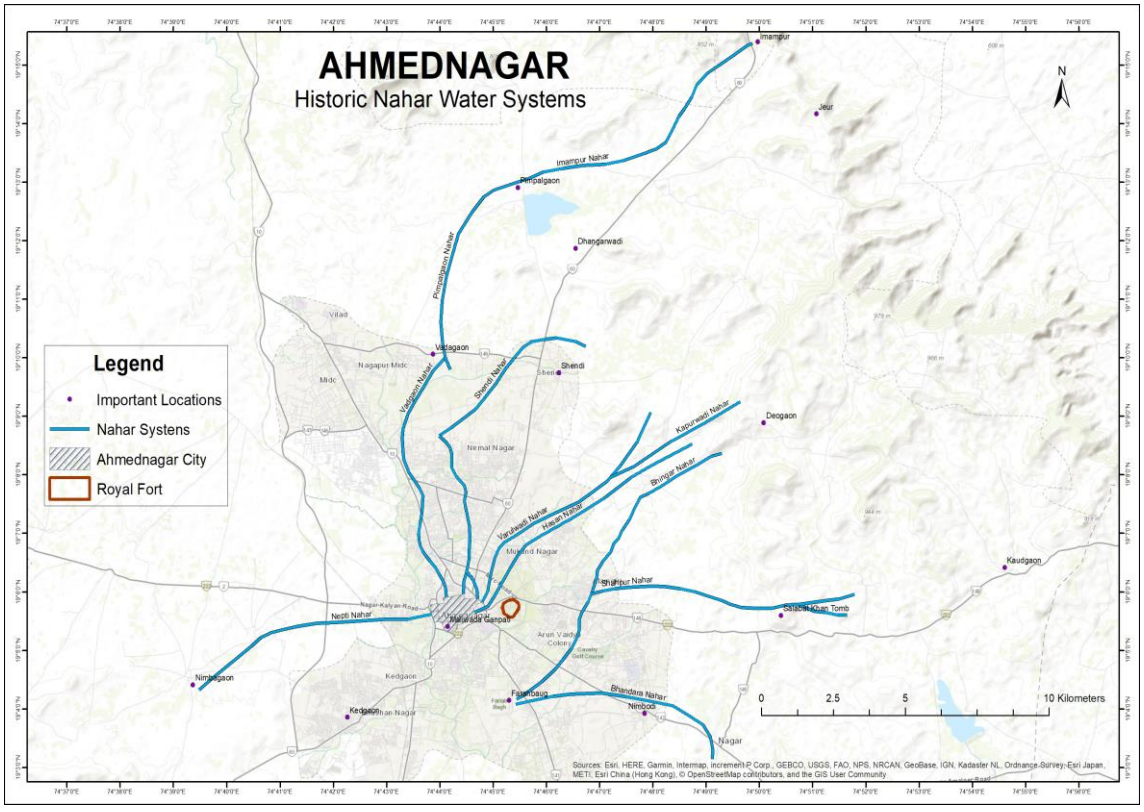

Figure 5: Historic Nahar Water Systems of Ahmednagar

Nahars of Ahmednagar

There are about fifteen Nahars or adits constructed between the years 1490 –1636 during the rule of Nizam Shahi Kings (Gadre, 1986) (Figure 5). Most of these Nahars

are located on the left bank of Sina River with source along the plateau escarpment slopes in the east and north east. The 1884 Gazetteer records eight of these Nahars in functional state and rest seven in either partially or fully ruined state due to siltation. Most of these Nahars are on an average 5-6 km in length with airshafts at every 10-20m or closer. Most of the Nahars were constructed during the reign of Ahmad Nizam Shah Period (1490-1508), Burhan Nizam Shah (1508 – 1553) and Huasin Nizam Shah (1553-1565). The attacks on city during 1630 by Babuna son of Malik Amber did damage many of these water systems, but was by repaired later rulers including Aurangzeb (Gazeteer of Aurangabad, 1884; Gadre, 1986). Most of these water systems are of higher order from use of technology in transporting water when compared to Bidar Karez systems. The source in most cases is an open well of octagonal shape, and in some cases small reservoirs or tanks. The water was carried through subterranean channels of shallow depth of 10-12m. The 15 Nahars of Ahmednagar and purpose of construction is detailed in Table 3.

Table 3: Nahars of Ahmednagar

Sl. No.	Nahars	Year of Construction	During the Reign of	Constructed by	Utility
1	Vadagaon Nahar	1490-1508	Ahmad Nizam Shah	Noble Salabatkhan	Watering of garden
2	Kapurwadi Nahar	1490 -1508	Ahmad Nizam Shah	Nobles Ikhtiyar khan, Qasim khan and Sidi Shamsherkhan	Water supply to the palaces of Ikhtiyar khan, Qasim khan, Sidi Shamsherkhan, Chingiz Khan, Kings Palace and the localities of Ganj, Kist Ali, Hattimpura and Malliwada.
3	Nagabai Nahar	1490 -1508	Ahmad Shah Nizam	Noble Chingiz Khan	Water supply to Bagh-i-Nizam
4	Shendi Nahar	1490 -1508	Ahmad Shah Nizam	Noble Salabat Khan	Water supply to Faiz Bakhsh Bagh
5	Bhingar Nahar	1508 - 1553	Burhan Nizam Shah	Nobles Salabatkhan Gurzi and Nymatakhan Dakani	Waters the Farah Bagh and to cisterns of Bhinger town
6	Nimbgaon Nahar	1508 - 1553	Burhan Nizam Shah	Noble Ni'mat Khan Samnani	Serving all the Buildings and great bath

7	Nepti Nahar	1508 - 1553	Burhan Nizam Shah	Noble Ni'mat Khan Samnani	Serving all the Buildings and great bath
8	Imampur Nahar	1508 - 1553	Burhan Nizam Shah	Noble Salabatkhan Gurzi	Supplements Water supply to Faiz Bagh
9	Pimpalgaon Nahar	1508 - 1553	Burhan Nizam Shah	Noble Salabatkhan Gurzi	Water supply to Hashi-Bahist Bagh
10	Nagapur Nahar	1508 - 1553	Burhan Nizam Shah	Noble Cheinghiz Khan	Water Supply to Chingiz khan palace and his Hammam (bath)
11	Varulwadi Nahar	1553 - 1565	Husain Nizam Shah	Nobles Murtaza khan Fikiti and Farhad Khan	Joins Kapurwadi Nahar
12	Bhandara Nahar	1553 - 1565	Husain Nizam Shah	Salabatkhan Gurzi and Ni'mat Khan Samnani	Water supply for Farah Bagh
13	Shahpur Nahar	1508-1588	Started during Reign of Burhan Nizam Shah I and completed during reign of Murtaza Nizam Shah I (1565-1588)	Noble Salabatkhan II	Built to Supplement water supply to Farah Bagh.It is a feeder duct to Bhingar Nahar
14	Anandi Nahar	1633-1637	During Mughal Period under governorship of Sarjekhan	Anand Rao (probably a well-known merchant)	Water Supply to Anandi Bazar area
15	Bhavanipant Nahar	1633-1637	During Mughal Period under governorship of Sarjekhan	Bhavanipanth (Potdar - an official under Mughals)	It supplied water to his mansion in the western part of city

**Compiled by author*

Most of the Nahars at Ahmednagar of are either in ruins or completely destroyed due to the unplanned organic growth of urban area. Except for some of the octagonal mother well in the outskirts and few sections of Karez gallery in fort complex, its nearly untraceable. The Nahar's were similar to that of Nahar's at Aurangabad in construction and architecture.

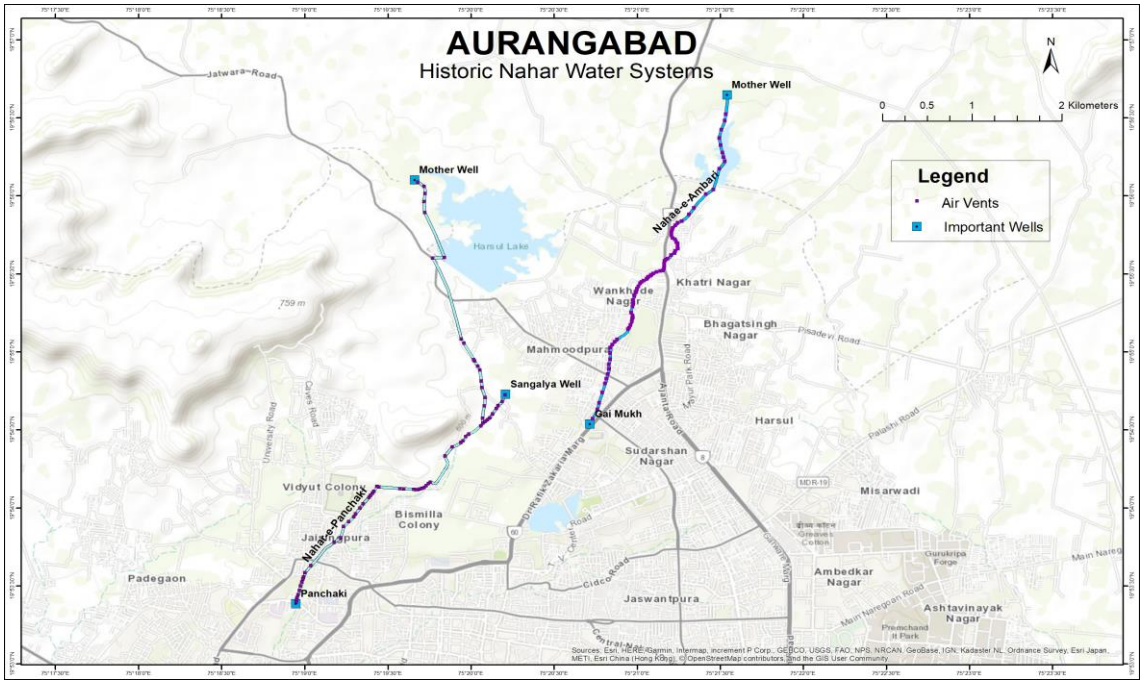

Figure 6: Historic Nahar Water Systems of Aurangabad

Table 4: Nahars of Aurangabad

Sl. No.	Nahars of Aurangabad
1	Nahar-i-Ambari, Shaha Ganj
2	Photi Nahar, Bhadkal Gate
3	Panchakki Nahar
4	Begampura Nahar (Thatte nahar-present name)
5	Palsi Nahar up to Baijipura
6	Latchman Doss Bairang's Nahar near Baijipura
7	Shah Ali Nahar near Deolgaon
8	Lall Munkirar's Nahar
9	Dul Baduls Nahar
10	Devlalli Nahar near Satara hills
11	Nahar-i-Lal Mahal
12	Nahar-i- Daragah Hajrat Shab Noor Hashmi
13	Nahar-i-Kiradpura
14	Nahar-i-Nasarullah

*Compiled by author

Nahars of Aurgangabad

The Karez Systems of Aurangabad are called as 'Nahars' literally meaning a channel supplying water (Figure 6). Malik Ambar (1549 -1626) was responsible for various development works both in Daulatabad and Aurangabad (Gazeteer of Aurangabad, 1884; Burgess, 1878; Gadre, 1986). The most known among them was the gravity flow water supply system known as *Kharejari* or *Nahar-i-Ambari* constructed in 1029 Hijri (1620 AD) (inscription at Gai Mukh) (Ramzan, 2010). Several such water channels were constructed across the city of Aurangabad to provide potable water to its citizens. Some of them are still functional though ill maintained. The Nahars developed in Aurangabad (Aurangabad Gazetteer 1884, Ramzan 2012, Mahadevaiah 2013), are: listed in Table 4.

These are highly complicated network of Nahar systems that uses both terracotta pipes as well as subterranean channels. The *Kham* River, *Bayan khan Nallah*, *Khizri Talao*, *Harsul Talao* are the main sources of Nahar's in Aurangabad.

The Nahar systems in Aurangabad is a combination of brick masonry conduits, terracotta pipe lines, water towers to source pressure, syphoning systems, waterfall for running floor mill etc. integrated together to provide 24x7 water supply to then urban population. Some of these Nahar's, namely the Nahar-i Ambari and Nahar-i-Panchaki is still functional and does supply water even during the drought conditions. The floor mill at Panchaki, the water towers to maintain source pressure and use of terracotta pipes make Nahar's of Aurangabad unique.

Rapid unplanned urbanization and organic growth of informal settlements have nearly erased some of these historic water systems. Some of the informal settlements have developed right over these Nahar Systems. The efforts have been on by Archaeological Survey of India to provide some protection through the existing laws have failed due to objections from residents along the Nahar's.

Kharejari of Bijapur

The historic urban hydraulic systems of Bijapur / Vijayapura are a combination of Surang-bhawi, terracotta/ceramic pipeline network, Ganj (water towers), manmade reservoirs (using mud/stone embankments) and Bawdi's (Cisterns). This multi-source water management system (Mate, 1998) was undertaken and completed during the reign of Bahmani and Adil Shahi kings (Sohoni & Klaus, 2012). It also showcases their knowledge on watershed management (Figure 7).

This water management system showcases the deep understanding of rainfall pattern, local terrain, geology, and aquifer properties. Deep understanding of local geography is reflected in spatial arrangement of three different types of water supply systems including the huge manmade reservoirs collecting run-off water. The three systems include the Kharejari / Karez system with extensive network of tunnels, pipelines and reservoirs, the Pipeline, *Ganj* Network from *Begam Talab (called 'Muhammed nada'),*

Ramling reservoir and the large cisterns across the city, connected either with pipeline network or Karez system (Nazim, 1836). These were not just urban water systems; they also supported the watering of gardens and irrigation of agricultural lands (Cousens, 1889).

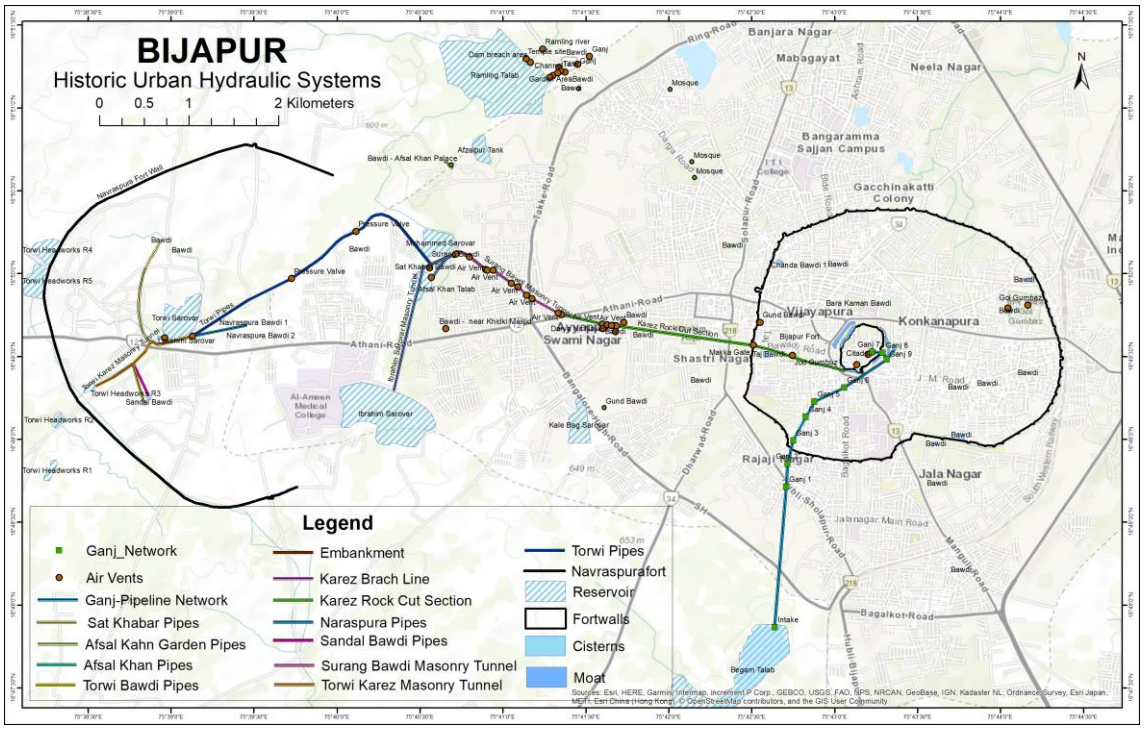

Figure 7: Historic Urban Hydraulic Systems of Bijapur

The Kharejari mother well '*Bhat Bawdi'* is located near Torwi 8km west of Bijapur, along with other headworks which includes stream bunds, constructed reservoirs, tanks/cisterns etc., and developed based on watershed management principles (Mate, 1998). Every stream has been tapped and bunds constructed to recharge groundwater or to directly feed the Karez gallery or through terracotta pipelines. The Kharejari tunnel which starts at Bhat Bawdi ends near Torwi Jami Masjid and further water is transported using terracotta pipelines. There are valves and pressure tanks enroute to *surang bawdi* where the pipeline culminates (Gazetteer-Bijapur, 1884; Cousens, 1889; Mate, 1998), These pipelines were laid to circumvent the upland area in between and carry water along same contour levels. *Surang Bawdi* is also connected by pipelines from *Afsal Khan Talab.* A Shallow tunnel brings water from *Ibrahim Sarovar* to *Sat Khabar Bawdi* and further carries it in terracotta pipelines to *Surang Bawdi*. From here wide yet shallow tunnel carries water for about two kilometres and enters into deep tunnel cut through hard basaltic rocks. The air vents can be seen of this section till *Ibrahim Roza*, further to this the *Kharejari* enters the fort near *Macca Gate* and proceeds alongside *Taj Bawdi*, *Jod Gumbaz* and culminates at inner moat (Cousens, 1889; Mate, 1998).

The Bijapur *Kahrejari* pipeline networks have near about completely destroyed. The shallow *Kahrejari* tunnel from *Bhat bawdi* to *Jami Masjid* and the branch tunnel from

Ibrahim talab to *Sat Khabar Bawdi* are in dilapidated state. The main *Kharejari* tunnel from *Surang Bwadi* to the city is contaminated with sewerage seeping into it from settlements above. The city lacks appropriate underground sewerage network and new settlements area keep cropping up. The shallow groundwater table tends to get polluted much faster under these circumstances. The zoning regulations under Karnataka town and country planning act could be used for protecting such masterpiece heritage entity. Lack of heritage sensitive plan is reflected in urban growth and neglection of these historic water systems.

Kundi Bhandara of Burhanpur

The work on urban water supply system commenced under the governorship of Abdur Rahim Khan Khanan during the period of Mughal Emperor Jahangir. The technique of qanat construction has a Persian lineage and the Mughals secured assistance of expert Persian geologist Tabkutal Arj to execute the work in 1615 (Wahurwagh & Dongre, 2015). The *Kundi Bhandara* system, the *Mool Bhandara* and *Chintaharan Bhandara* system, the *Sakkar Taloa -Bahadurpur* system, the *Mahal Gulara dam -Ahukhana* system and the *Kaladoh -Sindhipura gate* system are the six historic urban water supply systems constructed at Burhanpur during medieval times (Dewda & Mande , 2017) (Figure 8).

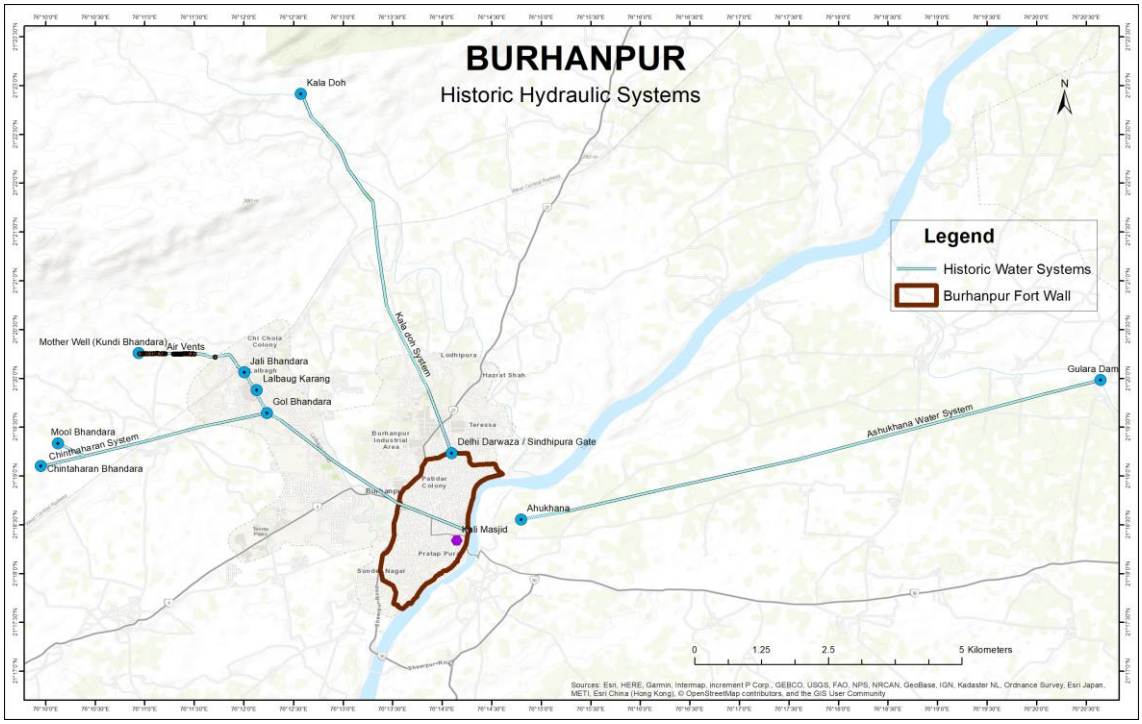

Figure 8: Historic Hydraulic Systems of Burhanpur

The main Karez line has three mother wells namely the Kundi Bhandara, Mool Bhandara and the Chintharan Bhandara, off these the Kundi Bhandara karez line is still active and has been protected by the local municipal administration and developed as a tourist spot. The other two line connect the Kundi Bandara Karez line is in dilapidated condition. The Karez gallery from Mool Bhandara joins the Karez gallery

from Chintaharan Bhandara and further it joins the main gallery from Kundi Bhandara at Gol Bhandara. The Water from all these three Karez lines reach Gol Bhandara and is further transported to walled city using a shallow underground tunnel with vents at equal intervals of 20m. Most of which has disappeared under urban built-up area. Further the distribution was carried out using terracotta pipelines running to main buildings and gardens. This Karez system has been dug through alluvial beds which fans out from the Satpura ranges. This is also the reason why the vents are round in shape with less than a meter in diameter. Thus, brick masonry with lime mortar construction protects the Karez gallery walls from collapsing.

Being a tourist destination developed by Burhanpur Municipal corporation some protection is accorded to Kundi Bhandara. But, this not enough to ensure its sustainability, major section of karez system between Gol Bhandara and Fort city has near about disappeared. The Karez gallery passes below railway lines before reaching Gol Bhandara, this section as well is blocked due to debris from roof collapse. Impact of urbanization and lack of awareness has taken its toll on the historic waters systems at Burhanpur. A major issue is also with use of pesticides in agricultural region from where the system originates, results it seeping through the sedimentary bed into water table.

The Karez system of Burhanpur is unique while comparing it to other Karez systems in India with round vents, thus looks similar to Persian Karez systems and is completely dependent groundwater.

Challenges and Opportunities

India is a rapidly growing economy with urban centres as engines of growth. Urbanisation and economic progress are concomitant processes. This is evident from the fact that, India's urban sector contributes around 62%-63% of GDP, which is likely to increase to 75 % by 2021 as per estimates of Ministry of Urban Development, Government of India. The cities are becoming economic centres of growth have resulted in their rapid spatial expansion as well. As a consequence of increasing economic and social prosperity, natural systems have been substantially exploited, depleted and destroyed. Being engines of growth, the Indian towns and cities are in rapid phase of growth. Our towns and cities face constraint of space for expansion or for providing better infrastructure. The urban expansion and infrastructure development activities tend to damage the cultural heritage and biophysical characteristics of land irreversibly. The damage to the functions performed by natural systems, their fragility in face of development is primarily due to poor planning, implementation, monitoring and management

Another important factor about Indian towns and cities is the long lineage of their cultural heritage. Most of Indian towns and cities have a historical core covering 25% to 30 % of its total area or may more in some cases. These heritage precinct and landscapes either gets erased or modified based on priorities set in urban planning and

development process. New infrastructure development, modern housing, better transportation networks, underground drainage network, 24x7 water supply are the priorities that tend to overlook the potential some of the historic entities exiting within city area can cater alongside modern amenities.

The present planning process does not assess the land and cultural resources for their capacities in ensuring sustainable development, rather considers it as commodity for sale. Land and cultural resources assessment provide a scientific basis for identification and selection of most appropriate, efficient use for a particular geographical space. The Master Plan preparation for spatial expansion and new infrastructure creation in town/city needs to be looked from perspective of incorporating assessment tools for land and cultural resources. This neglection is notable in JnNURM initiated infrastructure development to present smart cities programme, there is a gap in understanding and executing heritage sensitive development strategies.

The existing protection to the cultural and natural systems is accorder under certain policies, acts and laws of local, state and central government, along with conservation plans need to be integrated with urban expansion planning or the Master Plan. Some of these protections accorded include the Environmental Protection Act 1986, Land Revenue Acts of each state (e.g Karnataka Land Revenue Act – 192A-Section 95CA), Ancient Monuments and Archaeological Sites and Remains Act of each state, Town and Country Planning Act of each State, The Municipal Act of each State, The Municipal Byelaws of each local body and other these the national level Ancient Monuments and Archaeological sites and Remains Act 1958. Further to this are the UNESCO guidelines on conservation of heritage entities and landscapes.

Though these acts provide sufficient protection to cultural and natural heritage, very little could be implemented on ground or is very difficult to be implemented with the high density of population residing too close to the sites or within the sites like forts. There isn't any participatory approach either in implementation which leads to its failure. People's involvement is a must in protecting natural and cultural assets and can't be achieved only by implementation law.

Participation of people could open up several new opportunities and avenues in terms of protection, conservation, tourism, livelihood and many more. The opportunities in Karez systems conservation and management are immense in all the Deccani Karez cities. May be the Karez cannot be revived in all the cities, but can be protected to protect the groundwater resource and simultaneously developed for tourism. While some can be developed as decentralized water supply system serving both the domestic and agricultural needs, while others can serve as underground reservoirs and groundwater recharging structures.

Decentralized water supply systems if made sustainable will put less pressure on the centralized water supply system being adopted by the cities and most have failed to

provide 24x7 service to citizens. The development Karez system for tourism and as decentralized water supply systems enables protection of not just cultural heritage but also the natural heritage (groundwater and the landscape in this case). This also opens up the possibilities of developing better infrastructure and affordable housing for urban poor, mostly residing along these water systems in Deccani Karez cities like Aurangabad, Ahmednagar, Bidar etc. What is required is a landscape level conservation measure to be adopted in conserving these water systems and undertaking carrying capacity-based planning for each landscape unit (in this case Karez watersheds). Further to this an interpretative master plan and its implementation for these units will be instrumental in leveraging economic benefits through tourism.

Conclusion

It's not about masterpiece utopian master plan that's going to work and create a win-win situation for Deccani Karez system survival and people enjoying its benefits, but local level initiatives that are participatory in nature. Demand has to be generated at community level and worked upwards, rather than following the trickling down method. Education and lack of awareness is one of the key causes of neglection, destruction of cultural and natural heritage. Added to this is commodification and retailing of land and poor urban planning processes. We need to look at possibilities and opportunities for community based participatory planning and development approach rather than foreclosing options sustainable growth. Deccani Karez landscape present finest examples of watershed management and watershed-based city planning. Hope some of these can be emulated with aid of geospatial technologies at disposal for better decision making. Deccani Karez are the living water heritage of this country as testimony to urbanization of the Deccan region, making it possible to build cities deep inside semi-arid plateau region. Once protected and conserved they surely find a place in UNESCO world heritage sites.

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